JPL SURP Strategic Topic Areas - 2008

Topic Area:	5. Achieving Breakthrough Increases in Interplanetary Communications (100 – 1000 times current capabilities)
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The extreme challenge of communications over planetary distances is one of the distinguishing characteristics of solar system exploration. This Grand Challenge seeks to advance the current state of the art in deep space communications by two-to-three orders of magnitude with the goal of greatly enhancing the resolution of our "virtual presence" throughout the solar system. Just as the widespread availability of high-rate broadband computing infrastructure has totally changed how we use and experience the Internet, we envision that the targeted gains in our capability to transmit information across interplanetary distances will transform the way in which we explore the solar system and share that adventure with the public.

The current state of the art for interplanetary communications is embodied by the capabilities of the Mars Reconnaissance Orbiter (MRO), launched in 2005. With its 3-meter, 100-Watt X-band radio system, it can achieve data rates of order 1 Mbps on the link back to the antennas of NASA's Deep Space Network. Similarly, MRO supports UHF omnidirectional relay links to Mars surface landers (e.g., the Spirit and Opportunity rovers) at comparable data rates of up to 1 Mbps. This Grand Challenge aims to advance these capabilities to the 0.1 – 1 Gbps regime for Mars distances (and corresponding capabilities, scaled by $1/R^2$, for other planetary distances). In concert with this increase in raw data rate, we also envision advances in information technologies in order to more effectively utilize this increased bandwidth in terms of meaningful information flow.

Achieving this level of performance improvement will likely require advances in both flight and ground systems. Potential areas for fruitful research include:

- Deep Space Link Improvements
  - Migration to Ka-band and/or optical wavelengths
  - Increased spacecraft Equivalent Isotropic Radiated Power (EIRP) via high-power/high-efficiency power amplifiers and large aperture spacecraft antennas
  - Increased ground reception performance (G/T) via cost-effective ground receivers that combine large collecting area with low noise receivers.
- Relay Link Improvements
  - Migration to higher frequency RF and/or optical wavelengths with steered, directional relay links
  - Development of low-mass, low-power telecommunications payloads for resource-constrained *in situ* spacecraft (e.g., Mars surface landers/rovers)
- End-to-End Information Flow
  - Efficient modulation, channel coding, and communication network protocols
  - Data compression (source coding) for efficient channel utilization
  - Higher-level data strategies (e.g., on-board data mining) to maximize the information value of transmitted data